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Lee et al.

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(54) **INFRARED CIRCUIT FOR SINGLE BATTERY AND REMOTE CONTROLLER USING THE SAME**

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(73) Assignee: **Generalplus Technology Inc.**, Hsinchu (TW)

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(22) Filed: **Nov. 21, 2016**

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(51) **Int. Cl.**

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H05B 41/282	(2006.01)
H05B 37/02	(2006.01)
H05B 33/08	(2006.01)

(52) **U.S. Cl.**

CPC ***H05B 33/0818*** (2013.01); ***H05B 33/0842*** (2013.01); ***H05B 37/0245*** (2013.01)

(58) **Field of Classification Search**

USPC .... 250/338.2, 493.1, 495.1, 504 H, 504 R; 323/220, 290, 355, 363; 362/84, 85, 157, 362/249.13, 551, 612; 361/264

See application file for complete search history.

(56) **References Cited**

U.S. PATENT DOCUMENTS

8,491,151 B2 *	7/2013	Spartano	F21L 4/027	315/291
2003/0151909 A1 *	8/2003	Sid	H05B 37/0272	362/85
2010/0046211 A1 *	2/2010	Spartano	F21L 4/027	362/157
2011/0309771 A1 *	12/2011	Randall	H01G 5/014	315/307
2012/0026726 A1 *	2/2012	Recker	F21K 9/13	362/157
2014/0111979 A1 *	4/2014	Bushee	F21V 33/008	362/158

* cited by examiner

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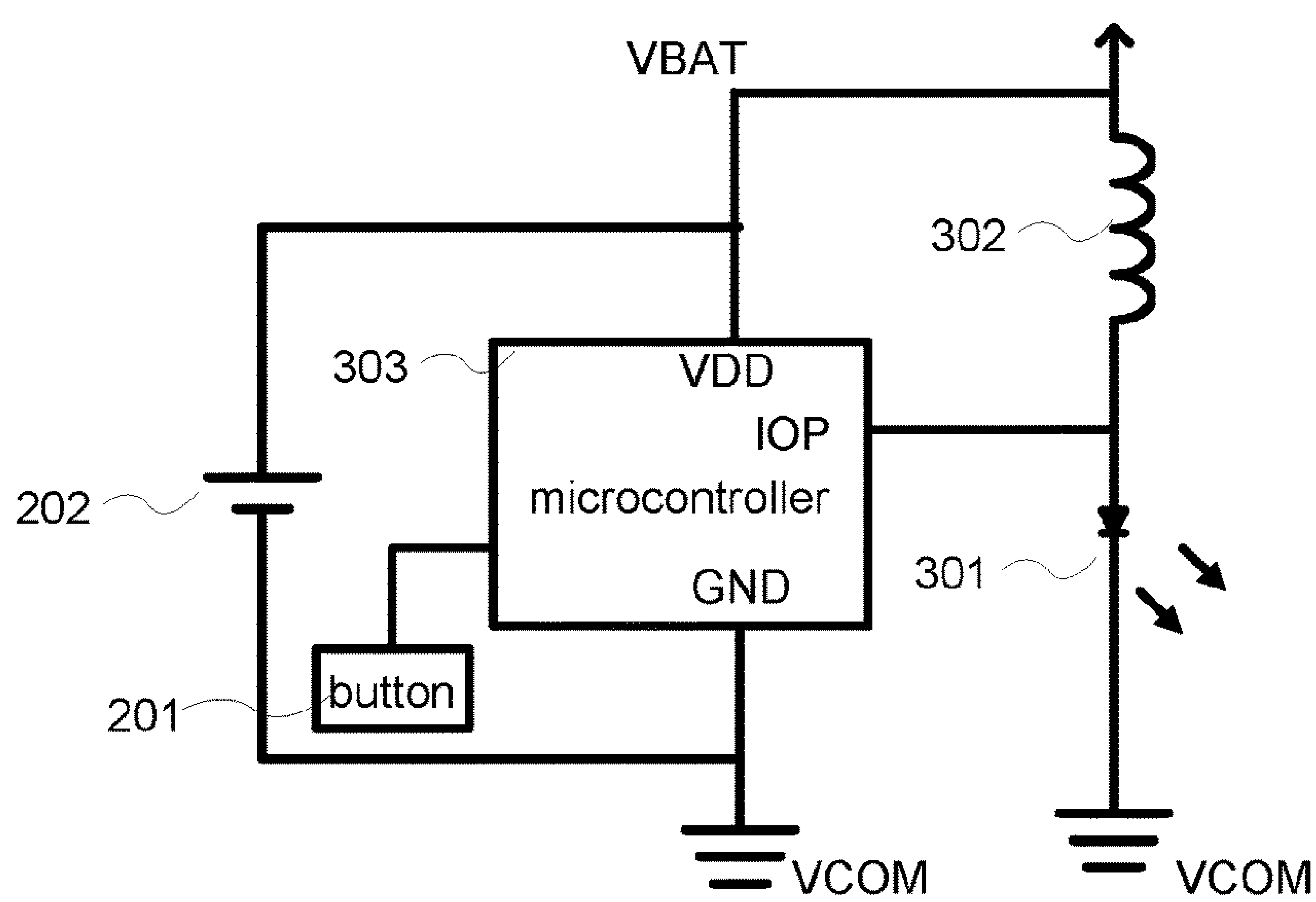
(57) **ABSTRACT**

An infrared circuit for a single battery and a remote controller using the same are provided. The single battery outputs a battery voltage. The infrared circuit comprises an IR LED circuit, an inductor and a microcontroller. The IR LED circuit is coupled between the battery voltage and a common voltage. The inductor is coupled between the battery voltage and the common voltage. The microcontroller has an I/O port coupled to the inductor and the IR LED circuit. When infrared rays are emitted, the microcontroller controls the battery voltage to charge the inductor through the I/O port, and a continuous current of the inductor forces the IR LED circuit to turn on.

18 Claims, 9 Drawing Sheets



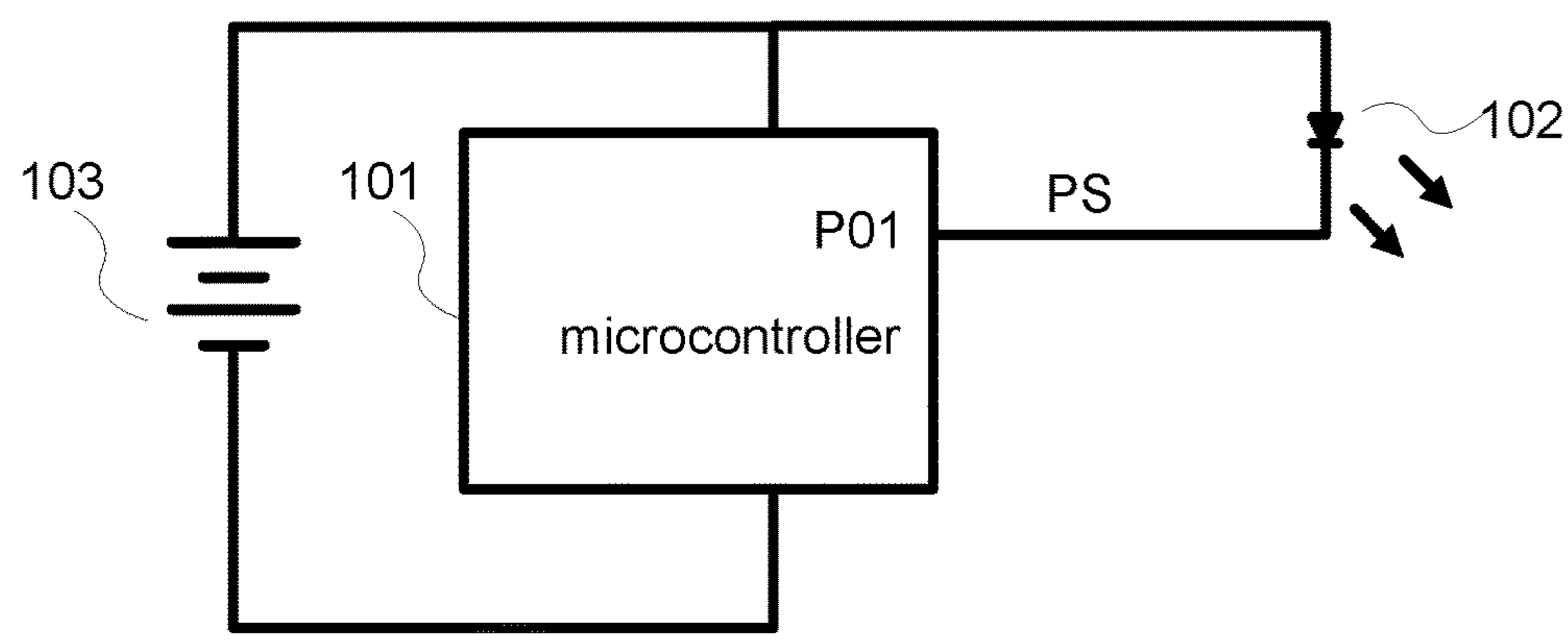


FIG. 1
(Prior Art)

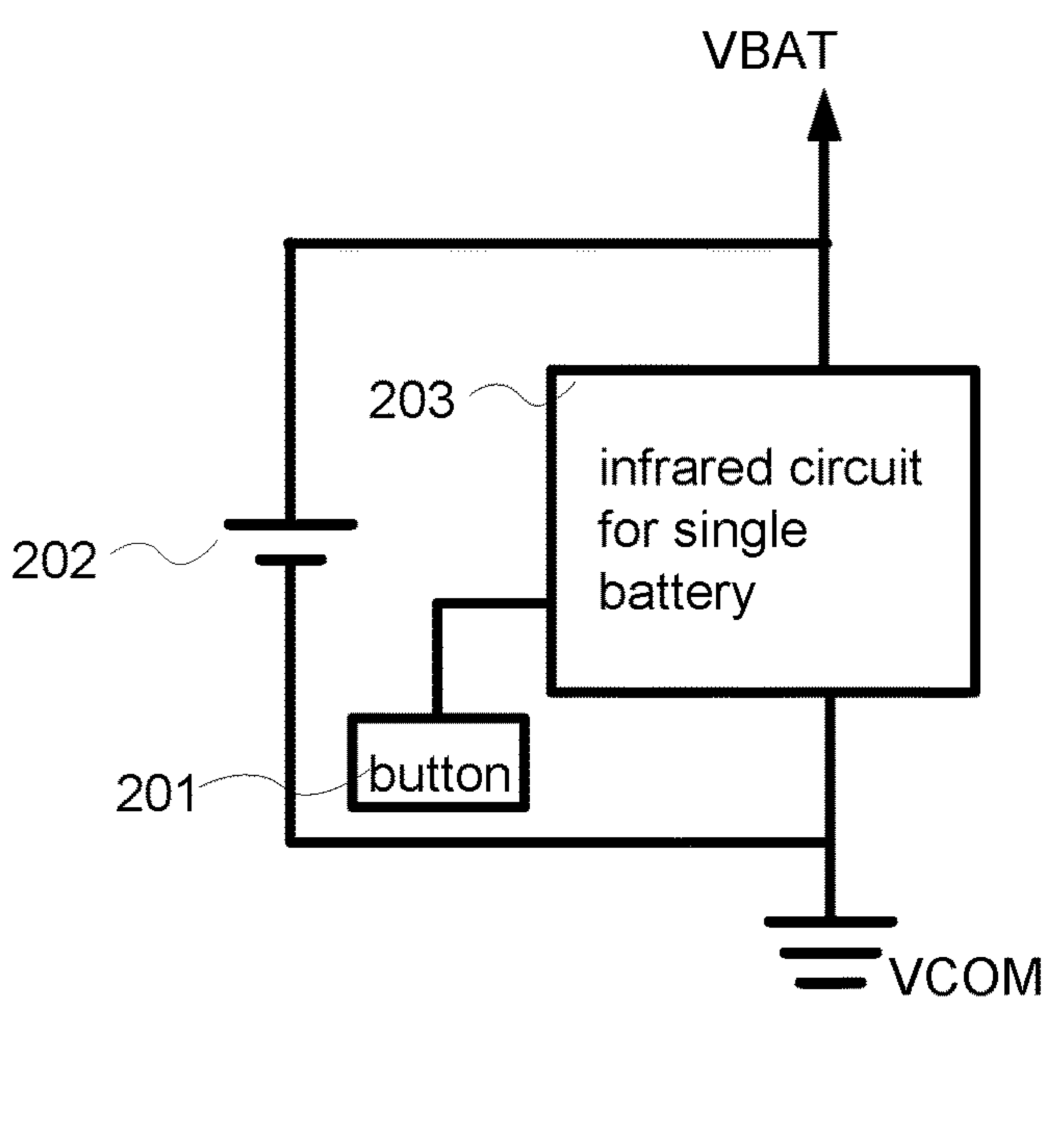


FIG. 2

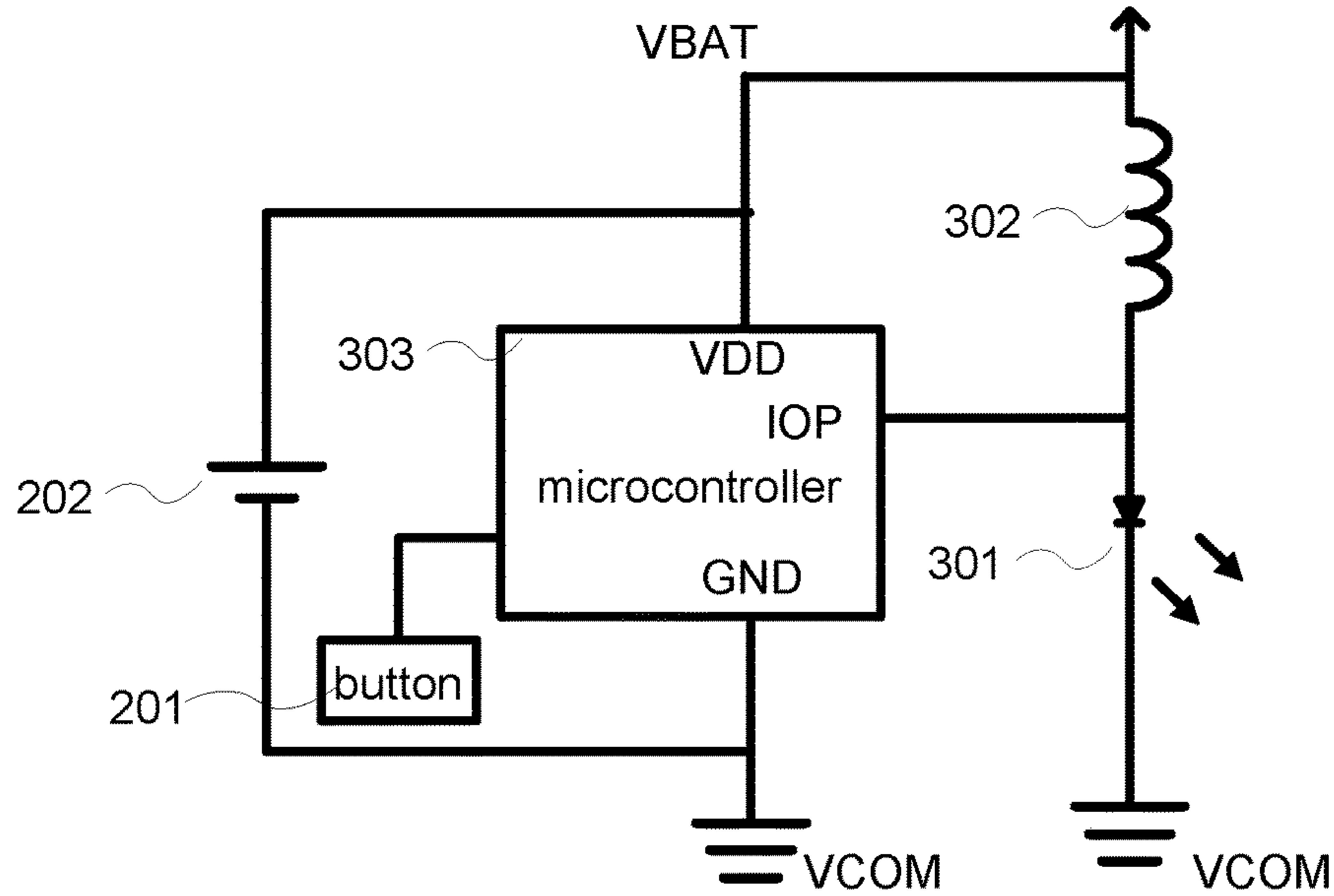

VBAT
302
303
VDD
IOP
microcontroller
202
301
GND
button
201
VCOM
VCOM

FIG. 3

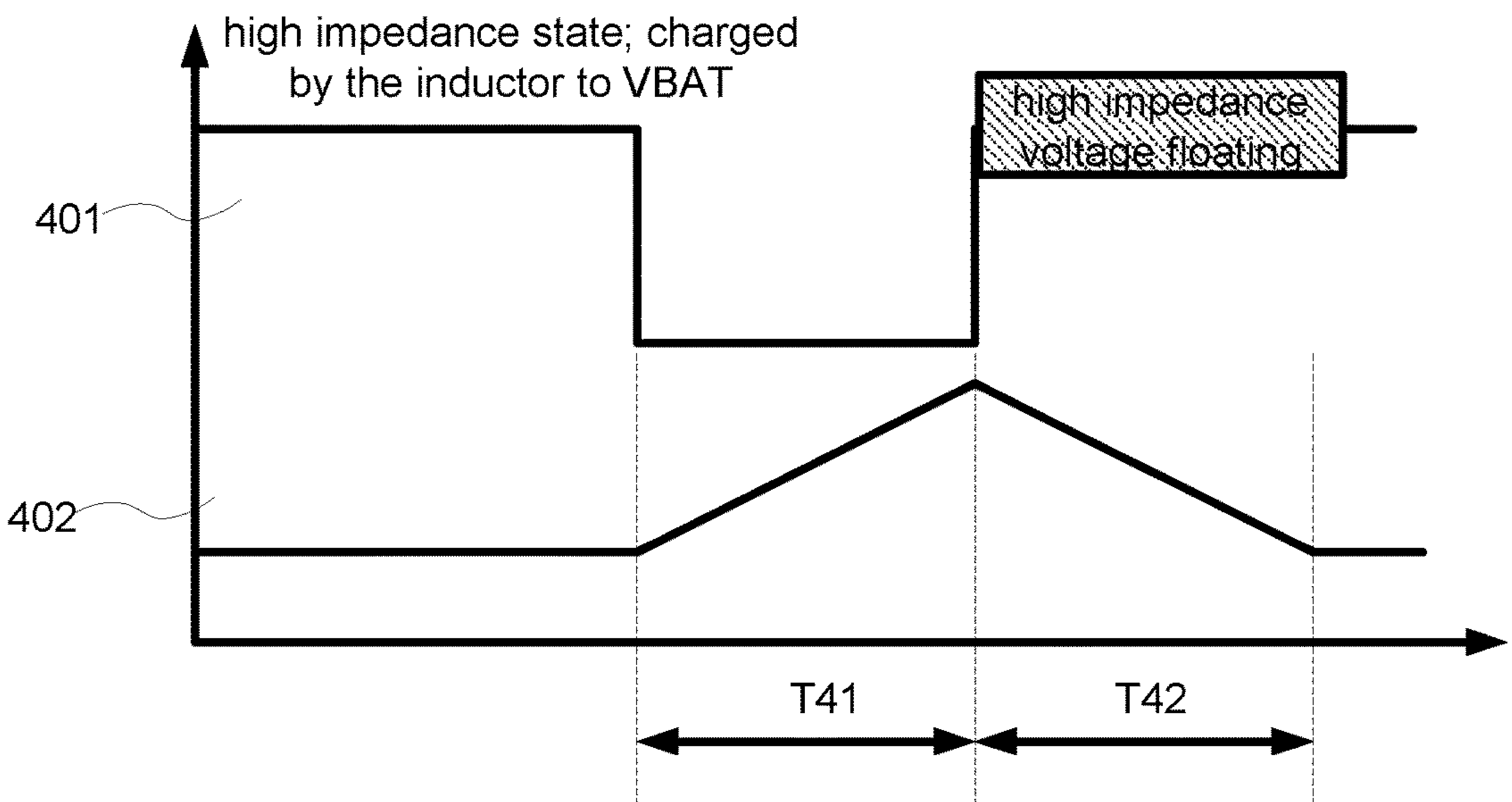
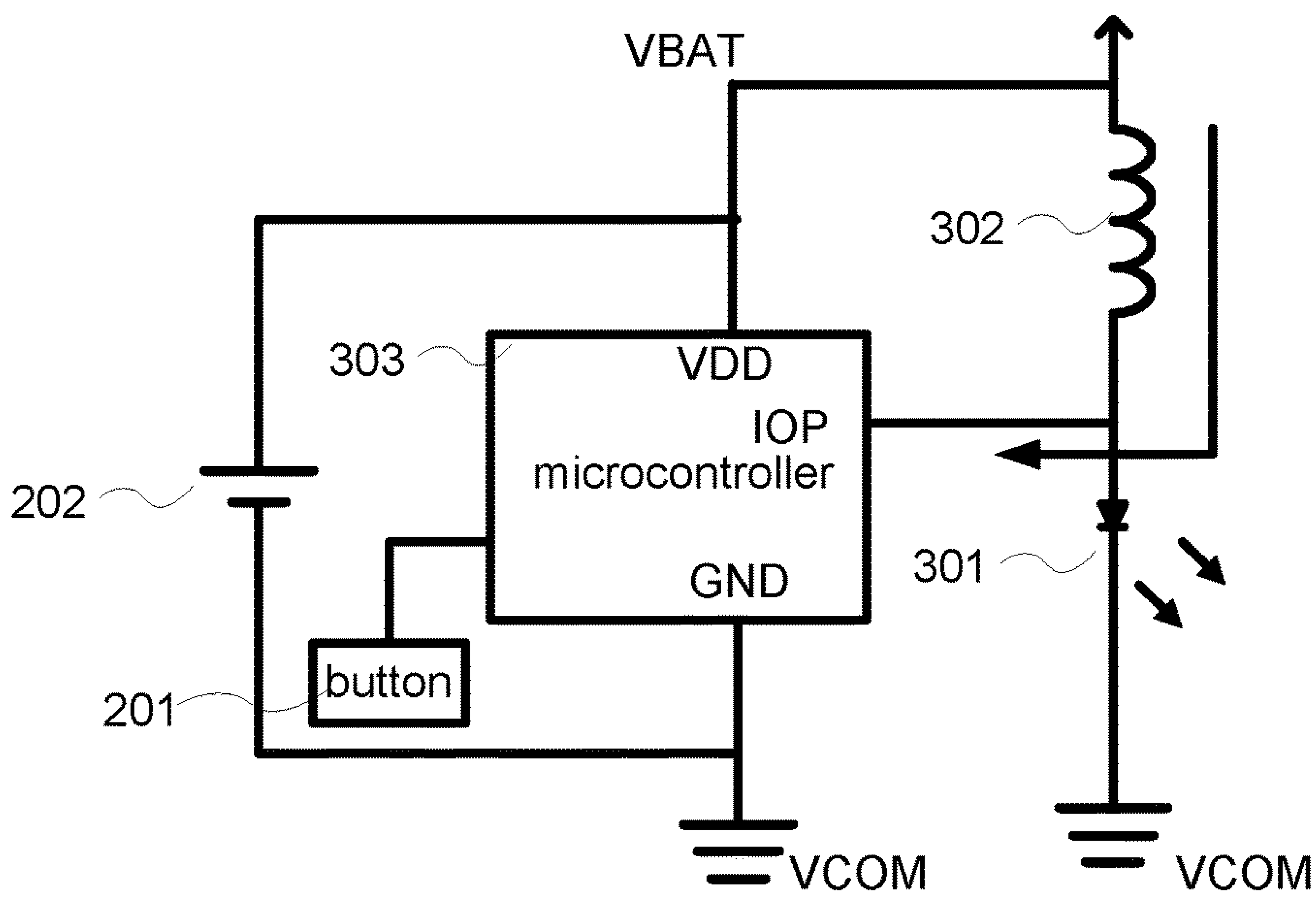
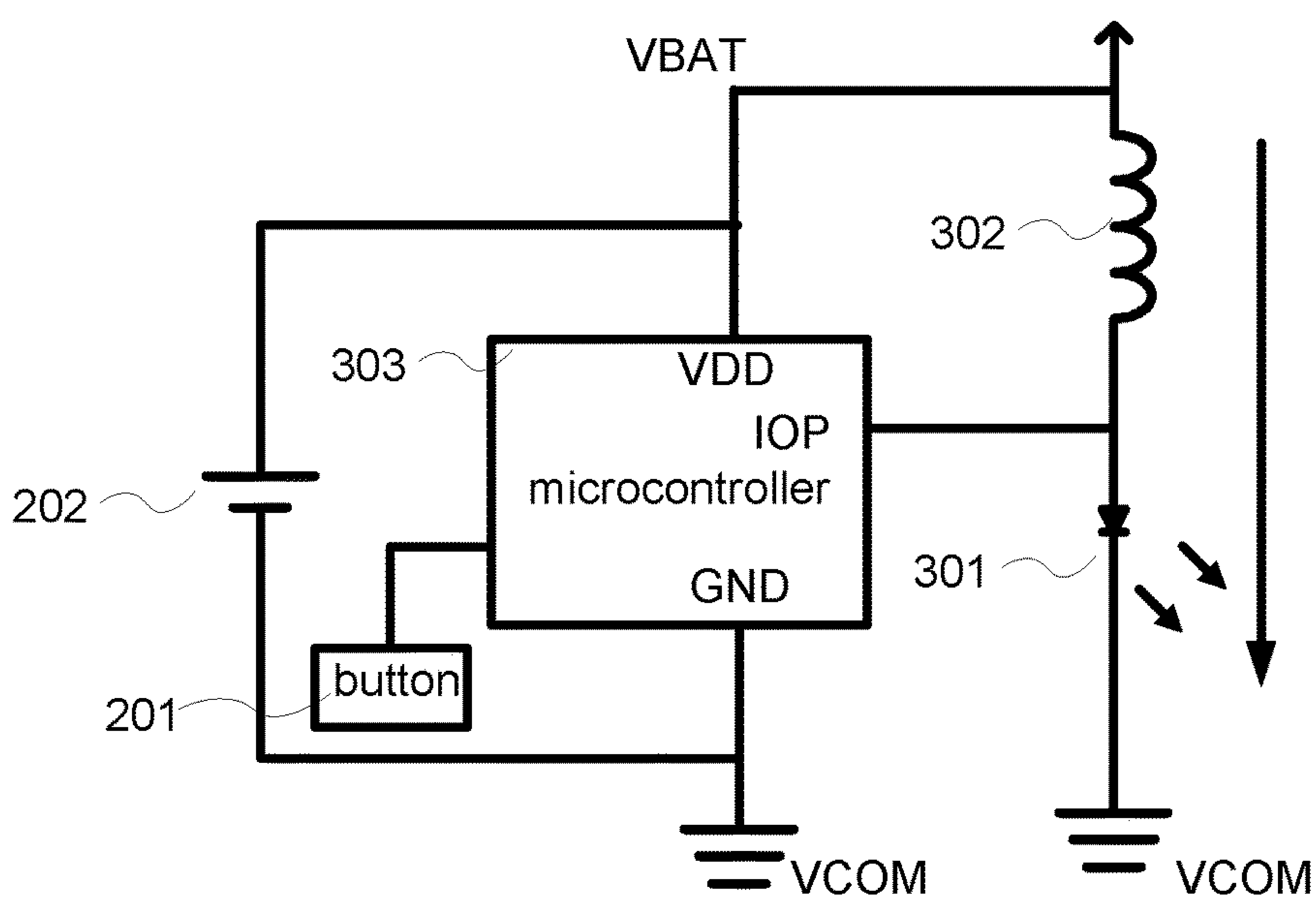

high impedance state; charged
by the inductor to VBAT
high impedance
voltage floating
401
402
T41
T42

FIG. 4



VBAT
302
303
VDD
IOP
microcontroller
GND
202
301
201
button
VCOM
VCOM

FIG. 4A



VBAT
302
303
VDD
IOP
microcontroller
GND
202
301
201
button
VCOM
VCOM

FIG. 4B

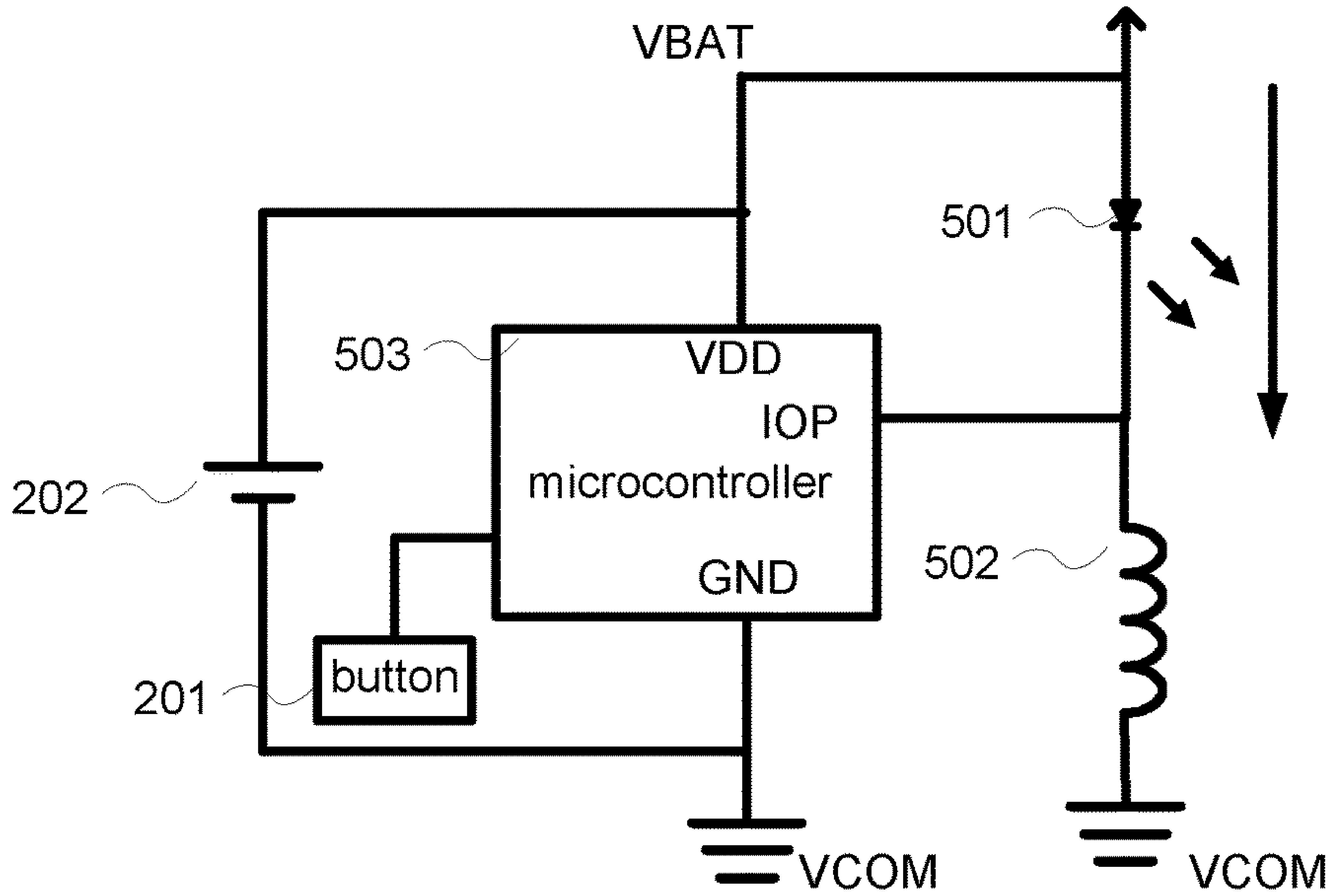

VBAT
501
503
VDD
IOP
microcontroller
GND
202
502
201
button
VCOM
VCOM

FIG. 5

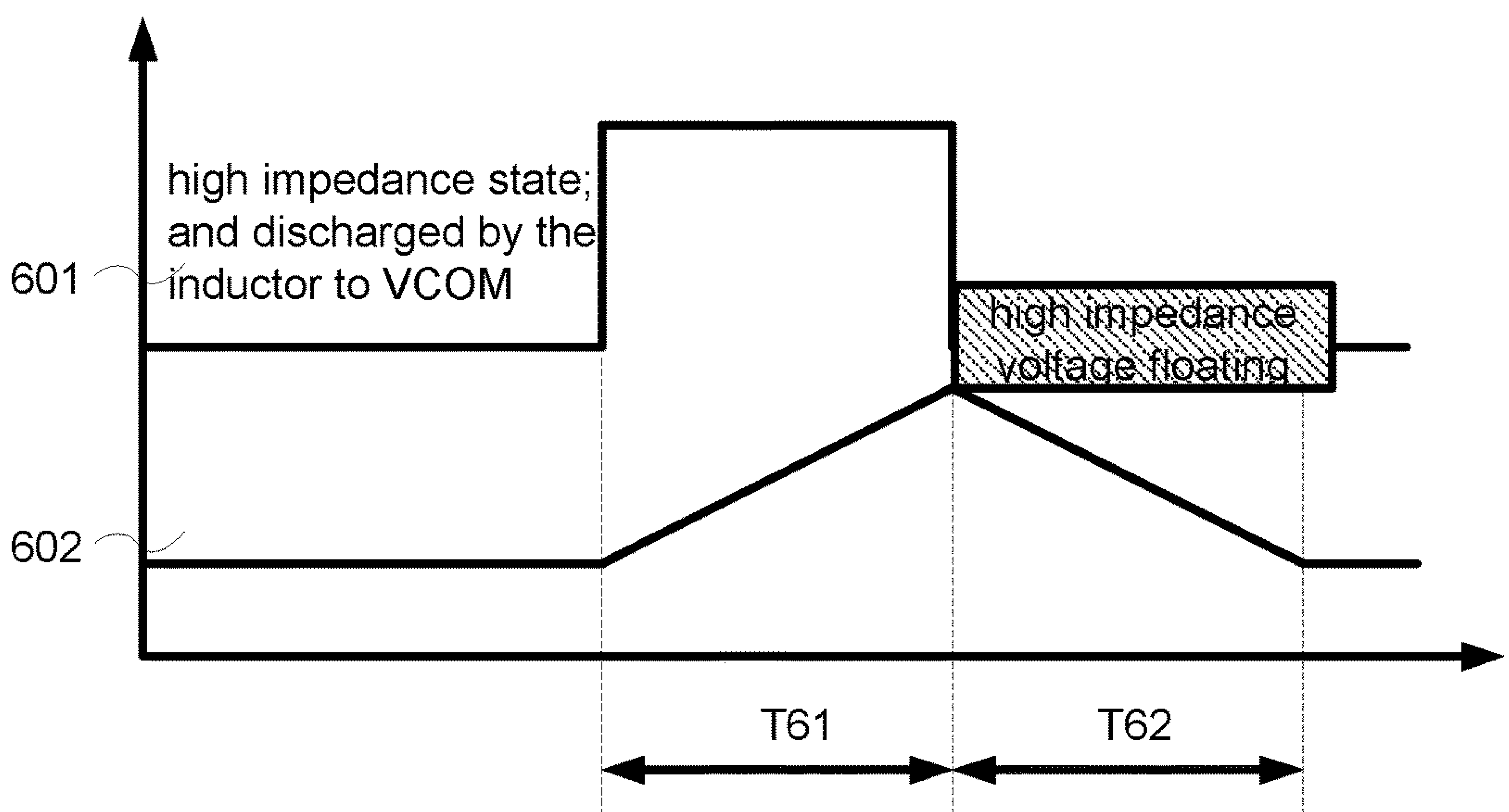

high impedance state;
and discharged by the
inductor to VCOM
601
high impedance
voltage floating
602
T61
T62

FIG. 6

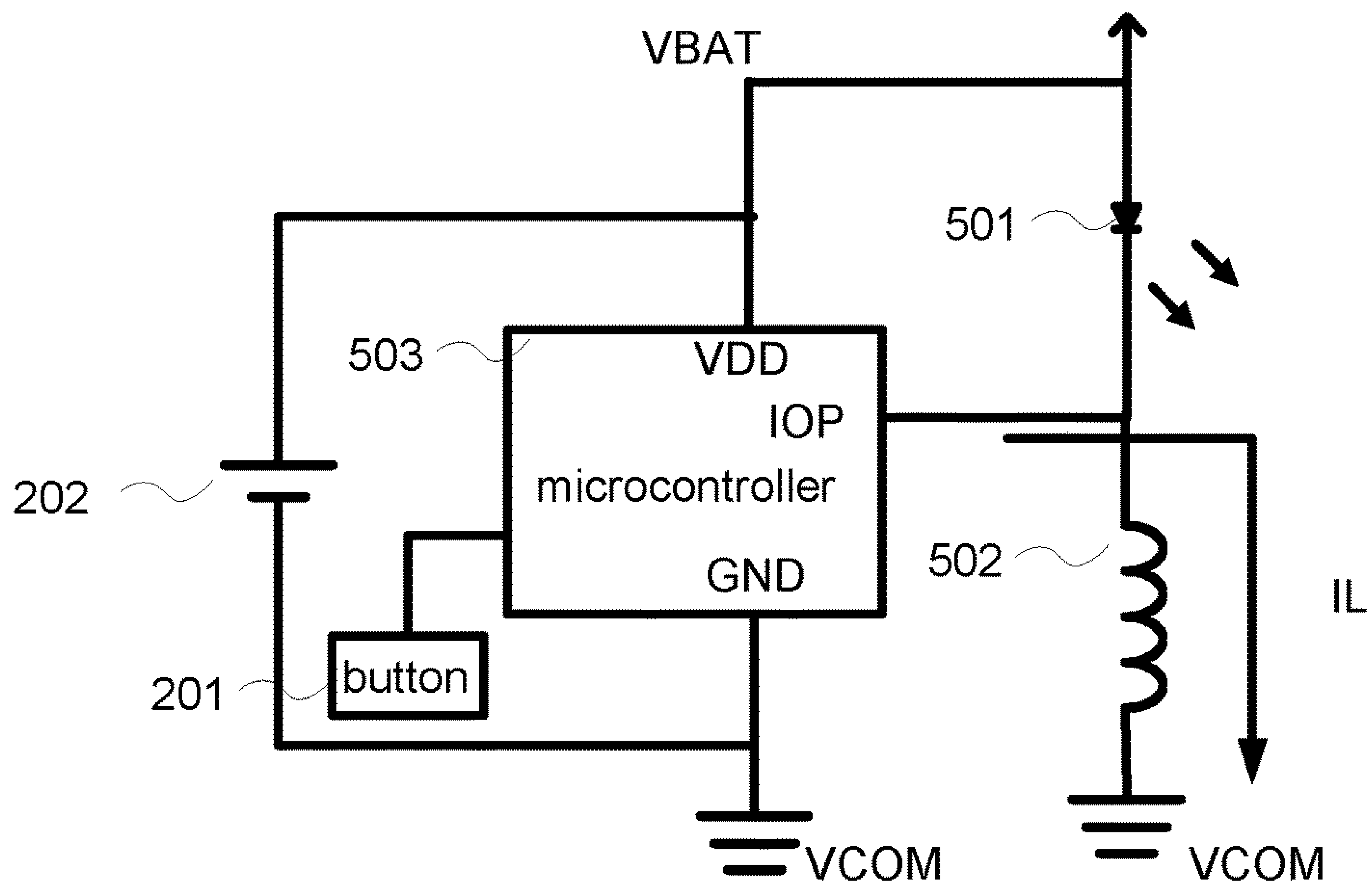

VBAT
501
503
VDD
IOP
microcontroller
GND
202
502
IL
201
button
VCOM
VCOM

FIG. 6A

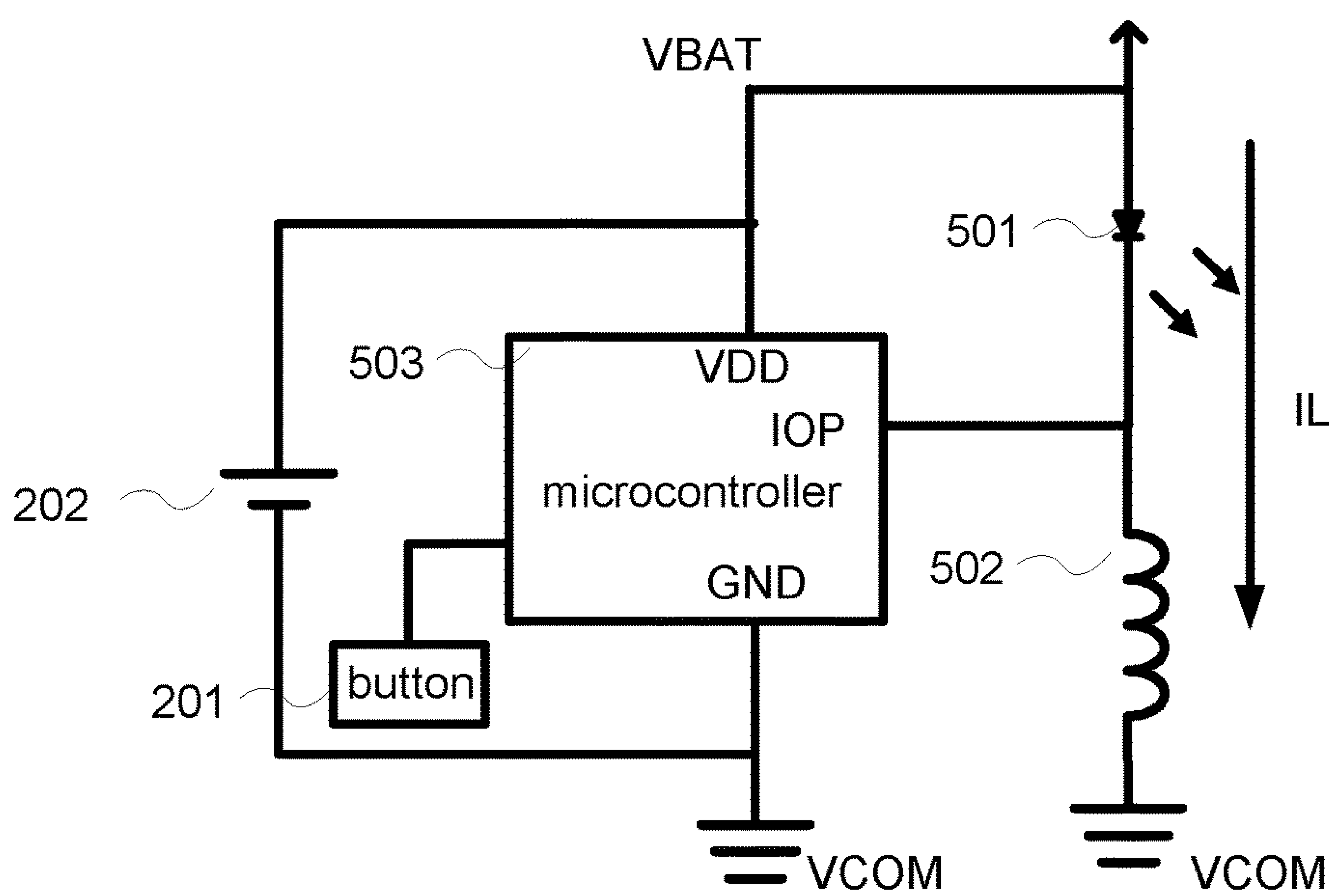

VBAT
501
503
VDD
IOP
microcontroller
GND
IL
202
502
201
button
VCOM
VCOM

FIG. 6B

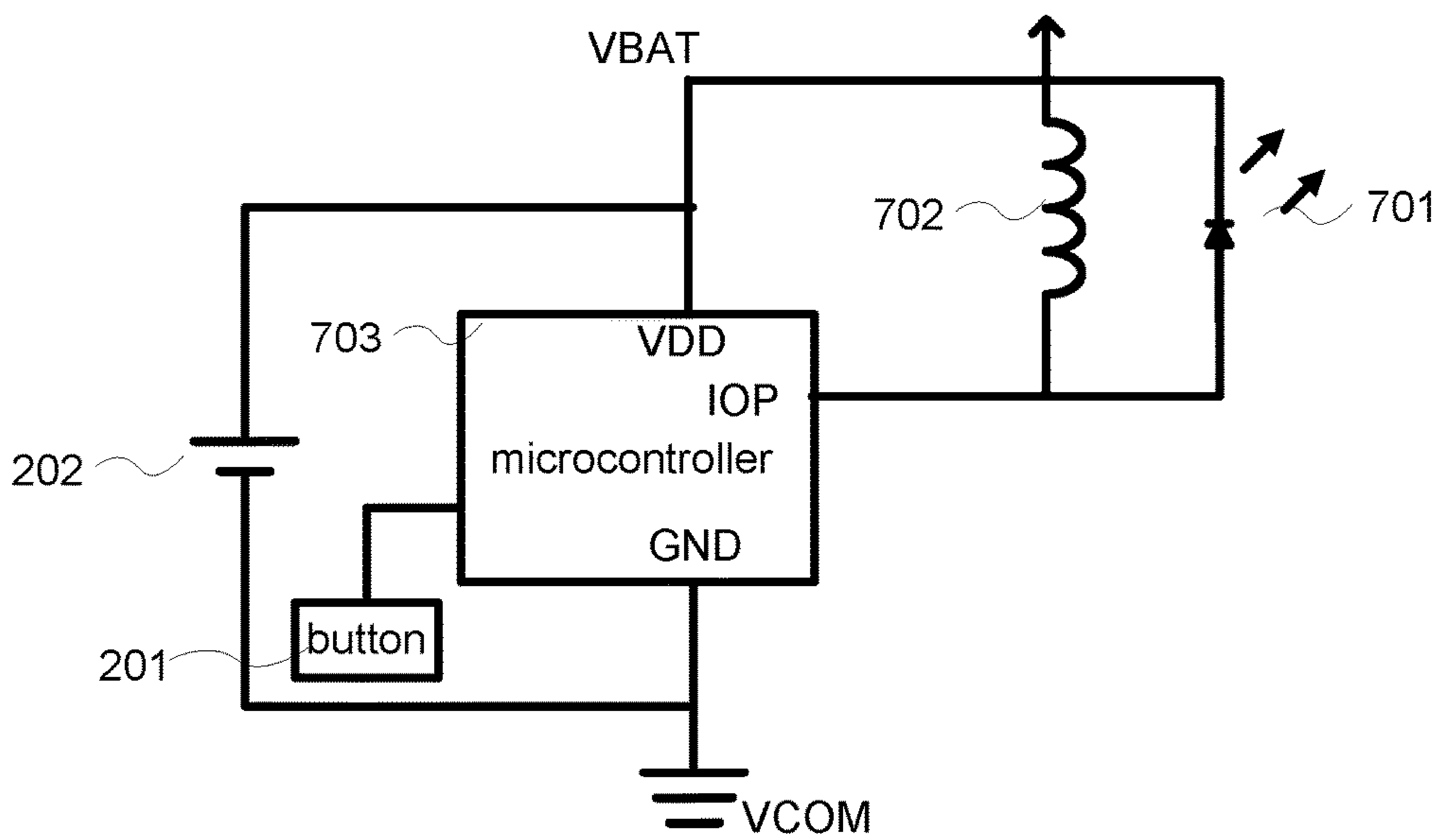

VBAT
702
701
703
VDD
IOP
microcontroller
GND
202
201
button
VCOM

FIG. 7

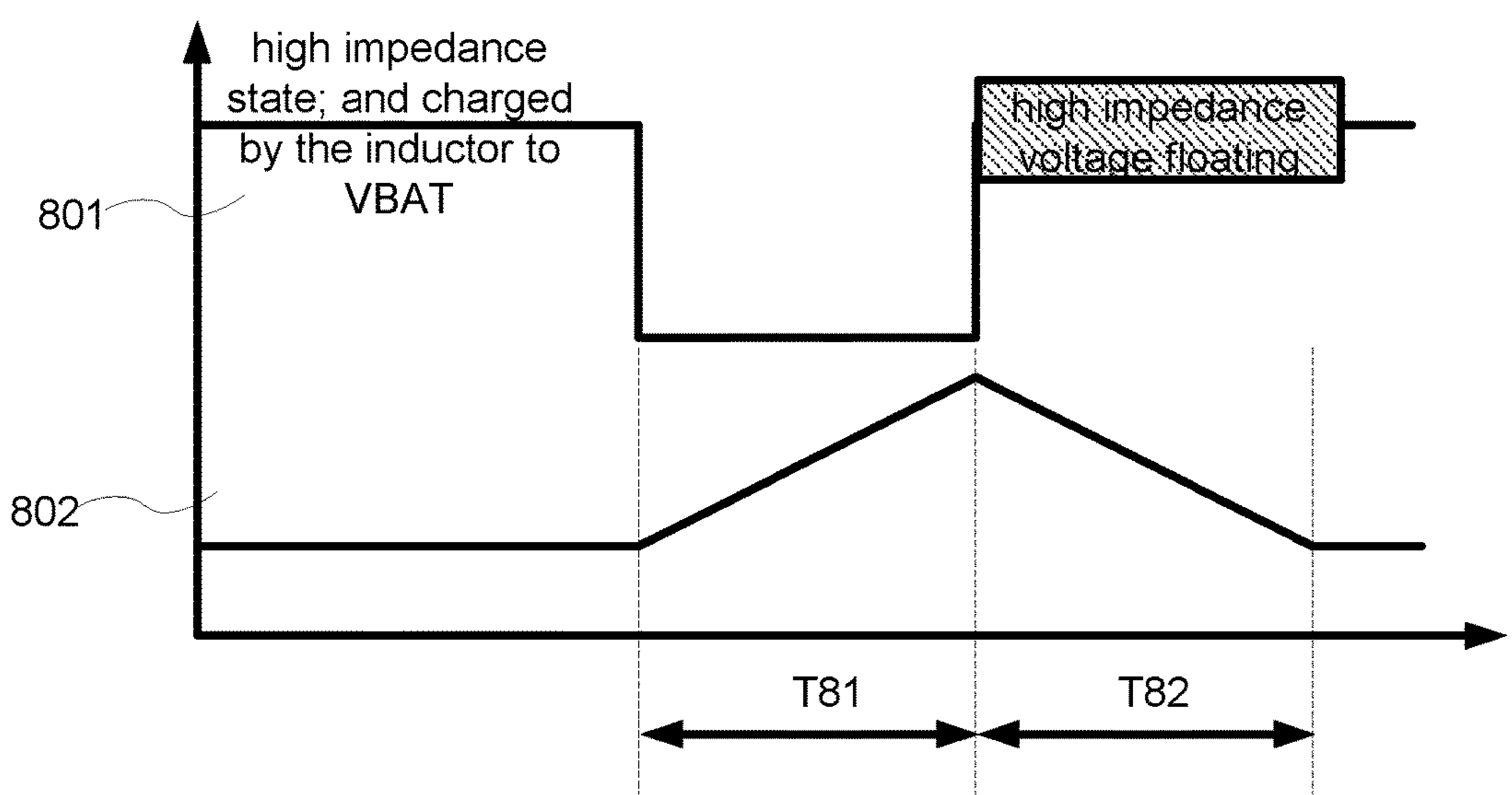
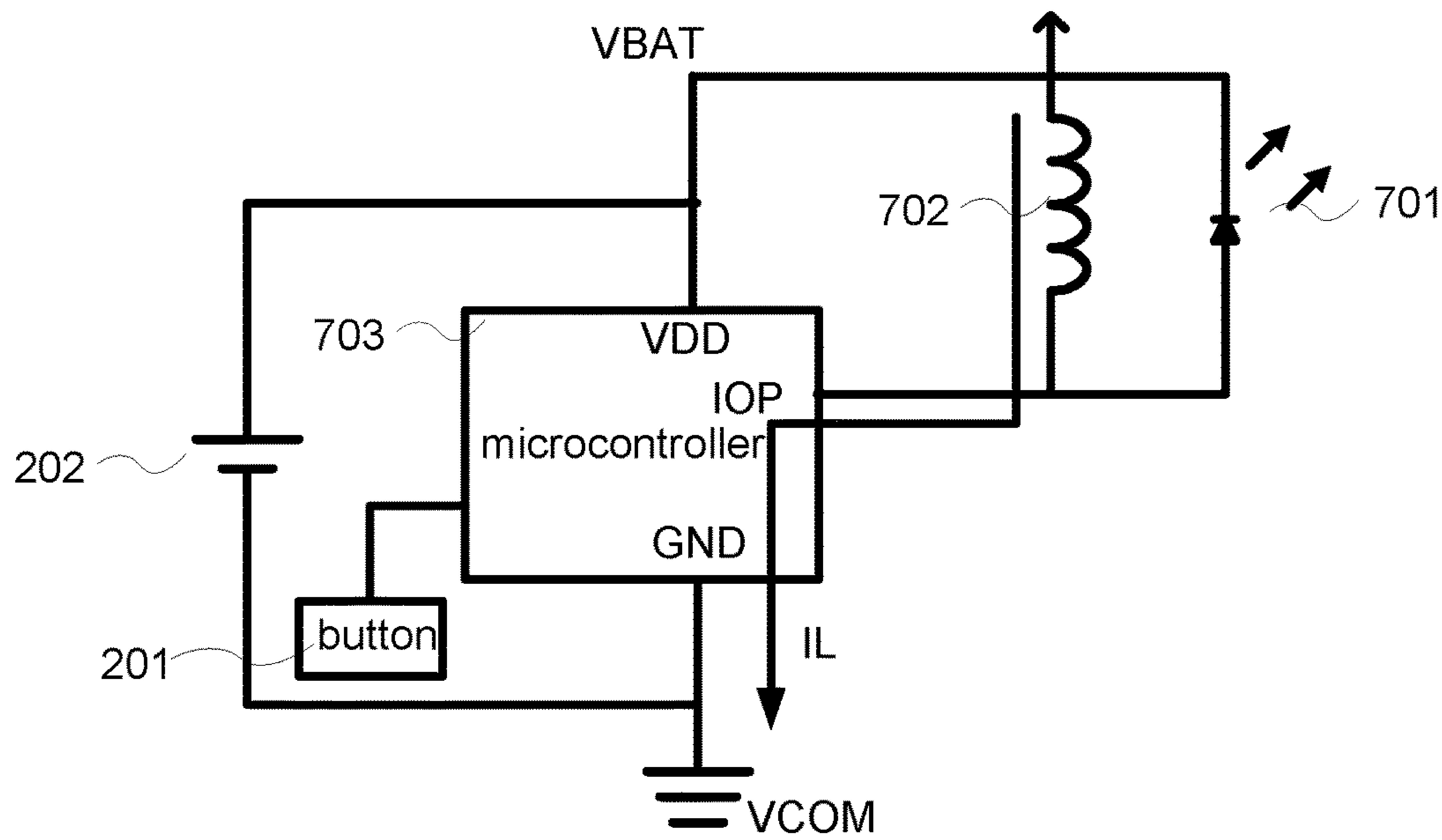
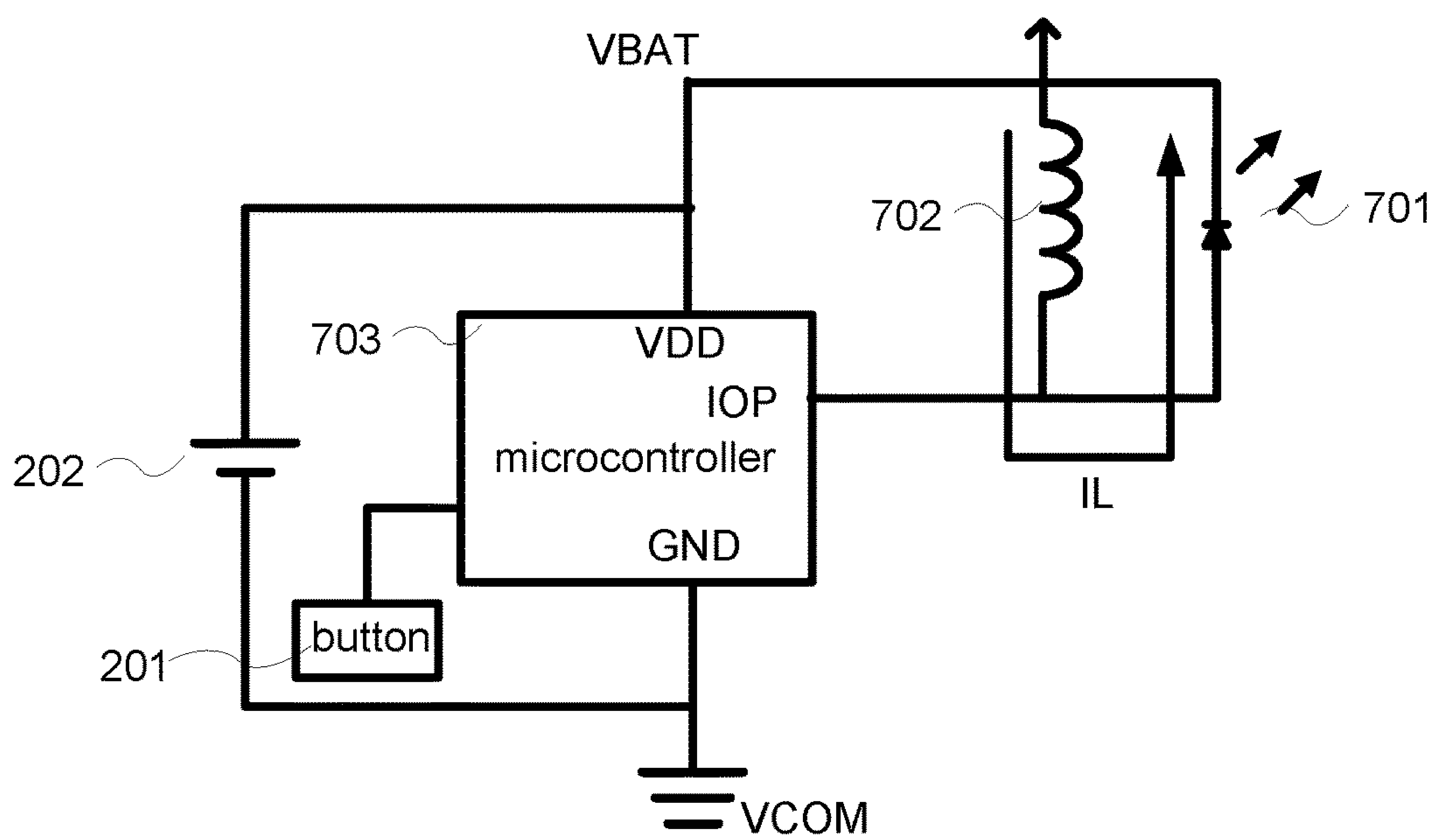

high impedance state; and charged by the inductor to VBAT
high impedance voltage floating
801
802
T81
T82

FIG. 8



VBAT
702
701
703
VDD
IOP
microcontroller
202
GND
button
201
IL
VCOM

FIG. 8A



VBAT
702
701
703
VDD
IOP
microcontroller
202
IL
GND
button
201
VCOM

FIG. 8B

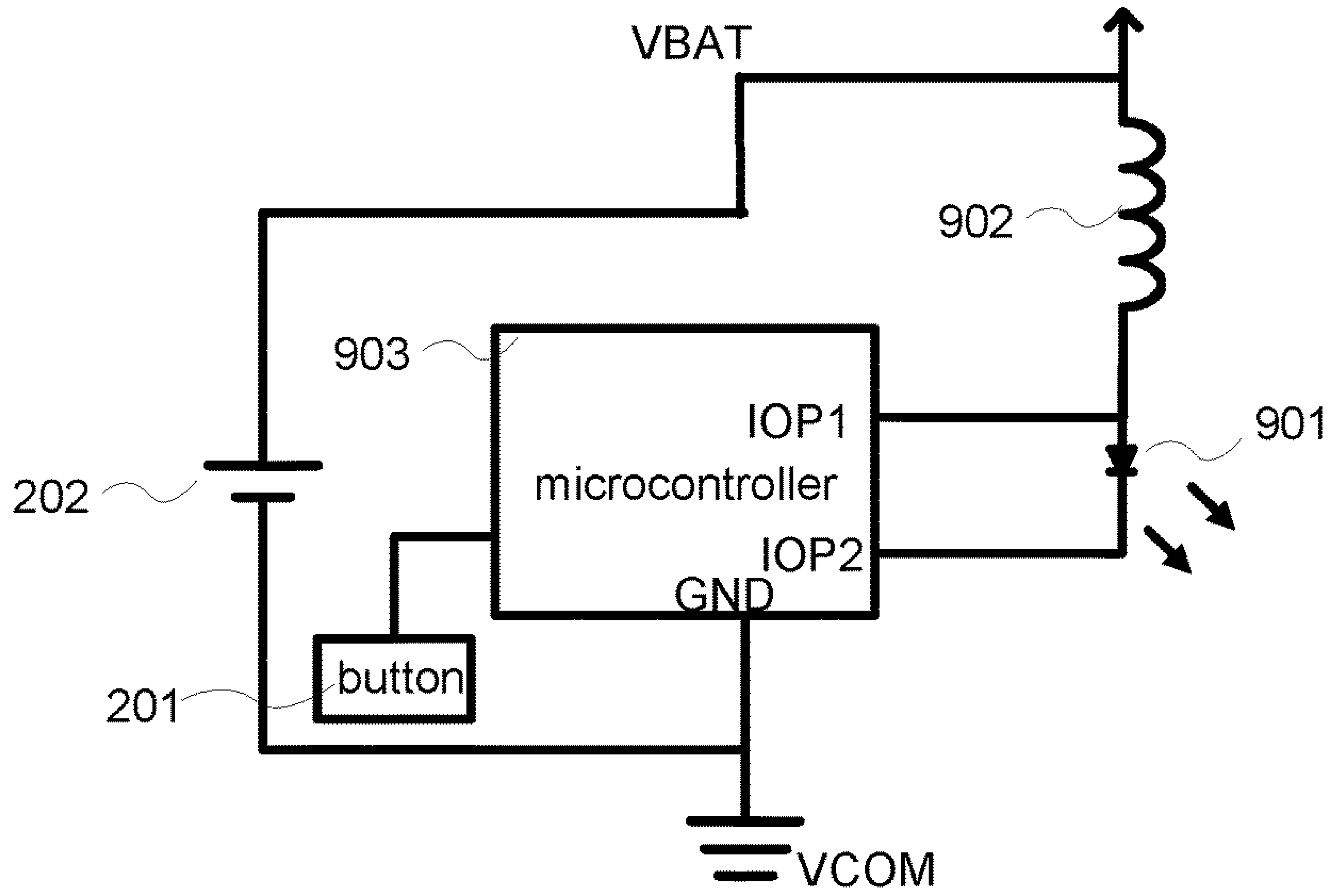

VBAT
902
903
IOP1
microcontroller
901
202
IOP2
GND
button
201
VCOM

FIG. 9

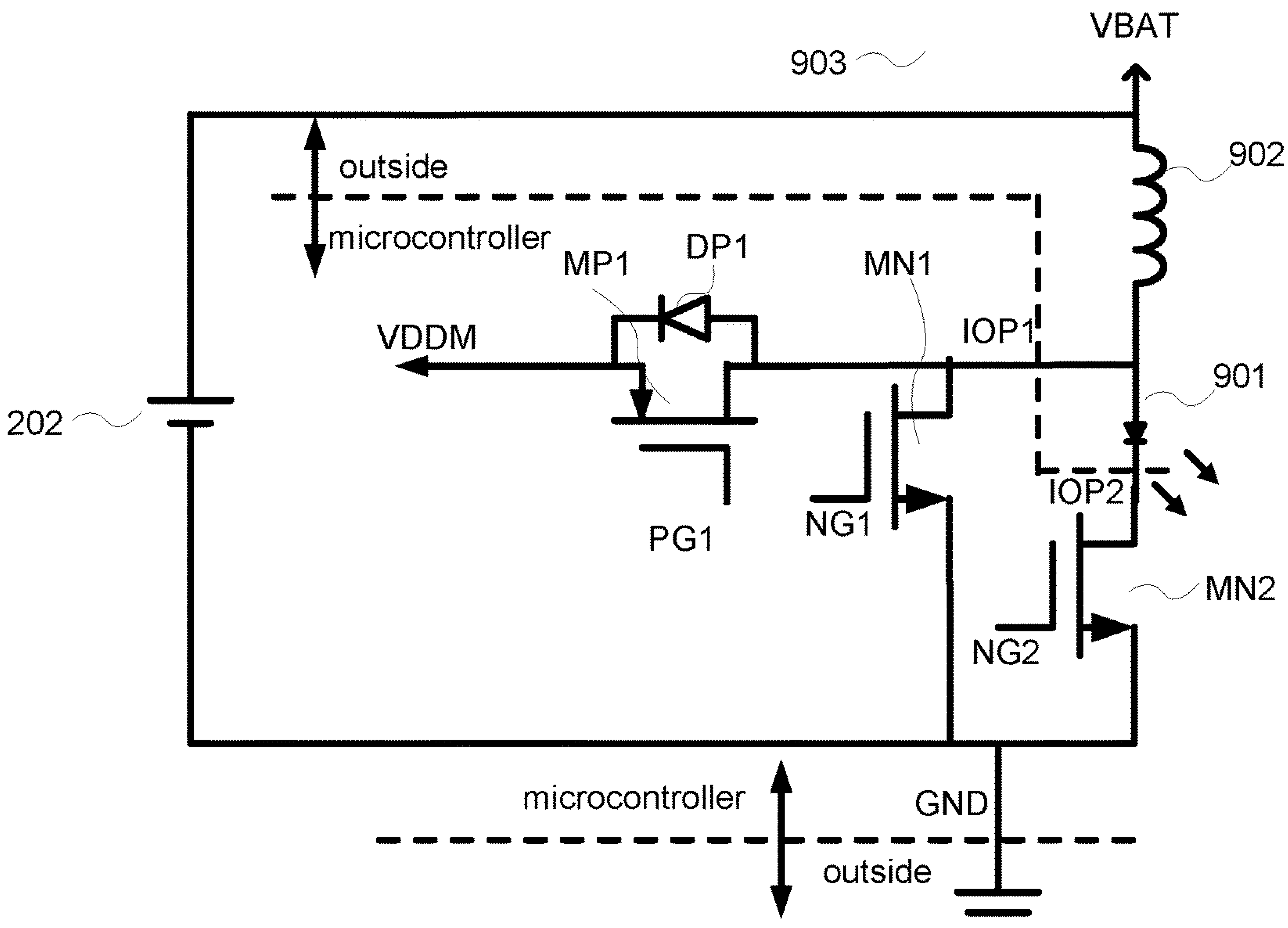

VBAT
903
902
outside
microcontroller
MP1
DP1
MN1
VDDM
IOP1
901
202
IOP2
PG1
NG1
MN2
NG2
microcontroller
GND
outside

FIG. 10

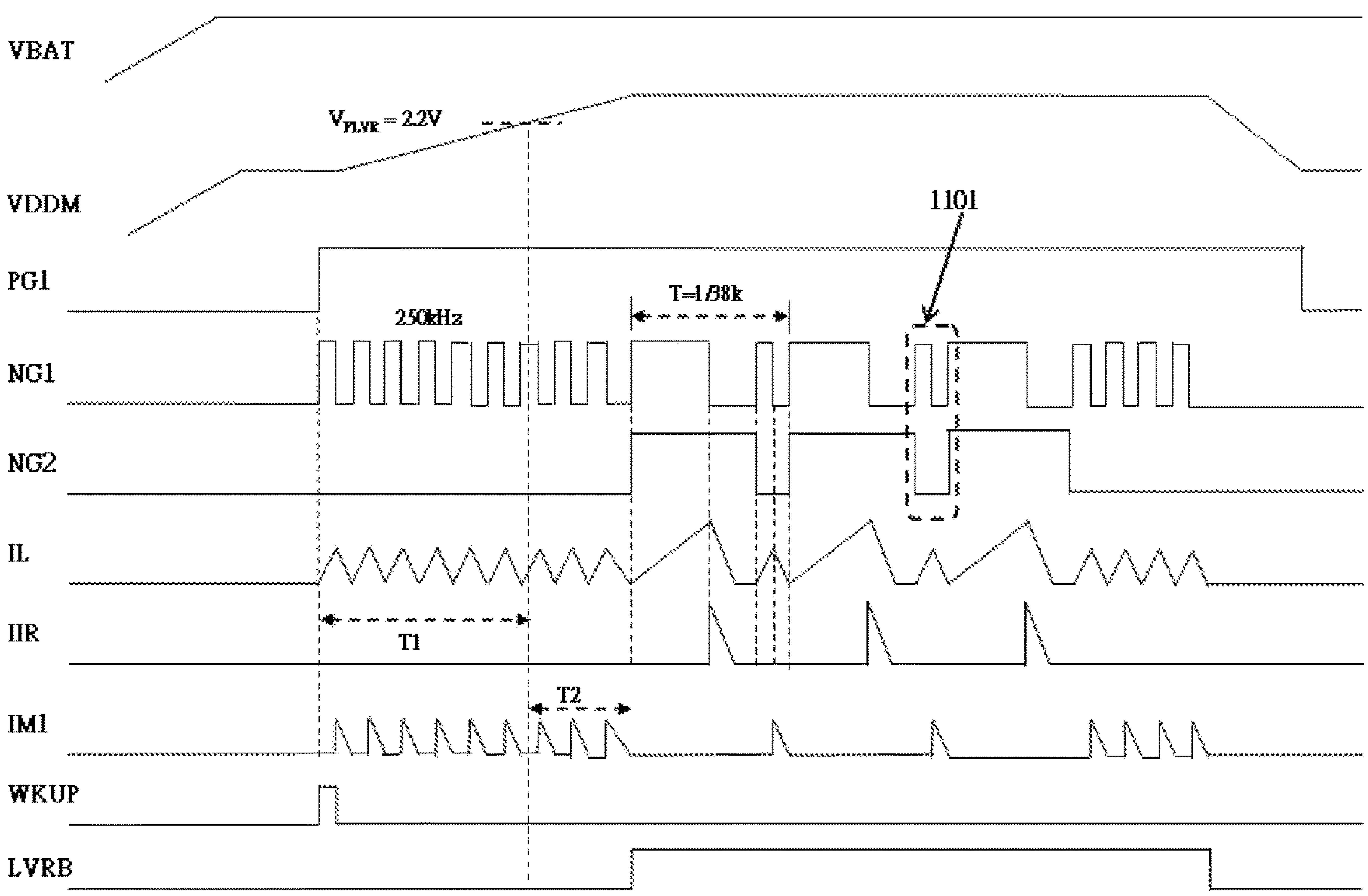

VBAT
V_FLVR = 2.2V
VDDM
1101
PG1
250kHz
T=1/38k
NG1
NG2
IL
IIR
T1
IM1
T2
WKUP
LVRB

FIG. 11

INFRARED CIRCUIT FOR SINGLE BATTERY AND REMOTE CONTROLLER USING THE SAME

BACKGROUND OF THE INVENTION

Field of the Invention

The invention relates to the infrared control technology, and more particularly to an infrared circuit for a single battery and a remote controller using the same.

Description of the Related Art

FIG. **1** is a circuit diagram showing a conventional device having an infrared emitting function. Referring to FIG. **1**, the device having the infrared emitting function comprises a microcontroller **101**, an IR LED **102** and at least two serially connected batteries **103**. The microcontroller **101** has an input/output pin P**01** coupled to an anode of the IR LED **102**. The microcontroller **101** outputs a pulse signal PS to the IR LED **102** through the input/output pin P**01**.

In the prior art, the threshold voltage of the IR LED **102** ranges from 1.0V to 1.5V, and the ordinary battery has the voltage of about 1.5V when no load is present. A no-load voltage of an unused new battery may approach 1.65V, and the voltage of the battery continuously decreases with the use of the battery. The battery may be regarded as failed after the voltage thereof is lower than 1.0V or 0.9V. When the battery is coupled to the load, the voltage thereof is decreased with the increase of the output current, and is often decreased to the voltage between 1.1V and 1.3V when an ordinary load is applied. The voltage of one battery may be higher than or lower than a threshold voltage of an infrared emitting tube. When the voltage is higher than the threshold voltage, the exceeded voltage value is too low. Thus, the current flowing through the IR LED is smaller, thereby causing the too-short emitting distance that cannot be accepted by the user. In addition, when the battery is used for a period of time, the voltage of the battery is lower than the threshold voltage of the IR LED. At this time, the IR LED cannot emit the infrared rays. Thus, the device with the infrared emitting function typically needs at least two batteries connected in series.

SUMMARY OF THE INVENTION

An object of the invention is to provide an infrared circuit for a single battery and a remote controller using the same, wherein only one single battery is used to drive an IR LED circuit having a threshold voltage equal to about a voltage of the battery.

In view of this, the invention provides an infrared circuit to be driven by only one single battery, which outputs a battery voltage. The infrared circuit comprises an IR LED circuit, an inductor and a microcontroller. The IR LED circuit is coupled between the battery voltage and a common voltage. The inductor is coupled between the battery voltage and the common voltage. An I/O port of the microcontroller is coupled to the inductor and the IR LED circuit. When infrared rays are emitted, the microcontroller controls the battery voltage to charge the inductor through the I/O port, and utilizes a continuous current of the inductor to force the IR LED circuit to turn on.

The invention further provides a remote controller comprising one single battery and an infrared circuit for the single battery. The single battery outputs a battery voltage. The infrared circuit comprises an IR LED circuit, an inductor and a microcontroller. The IR LED circuit is coupled between the battery voltage and a common voltage. The inductor is coupled between the battery voltage and the common voltage. An I/O port of the microcontroller is coupled to the inductor and the IR LED circuit. When a button is pressed down, the microcontroller controls the IR LED circuit to emit infrared rays according to the pressed button. When the infrared rays are emitted, the microcontroller controls the battery voltage to charge the inductor through the I/O port, and utilizes a continuous current of the inductor to force the IR LED circuit to turn on.

In the infrared circuit for the single battery and the remote controller using the same according to the preferred embodiment of the invention, the inductor comprises a first end and a second end, and the IR LED circuit comprises an anode end and a cathode end. The first end of the inductor is coupled to the battery voltage, and the second end of the inductor is coupled to the I/O port of the microcontroller. The anode end of the IR LED circuit is coupled to the I/O port of the microcontroller, and the cathode end of the IR LED circuit is coupled to the common voltage. When the infrared rays are emitted, the microcontroller controls the I/O port to output the common voltage, and then the microcontroller configures the I/O port as having high impedance, so that the energy stored in the inductor flows through the IR LED circuit.

In the infrared circuit for the single battery and the remote controller using the same according to the preferred embodiment of the invention, the inductor comprises a first end and a second end, and the IR LED circuit comprises an anode end and a cathode end. The first end of the inductor is coupled to the common voltage, the second end of the inductor is coupled to the I/O port of the microcontroller, the anode end of the IR LED circuit is coupled to the battery voltage, and the cathode end of the IR LED circuit is coupled to the I/O port of the microcontroller. When the infrared rays are emitted, the microcontroller controls the I/O port to output a power voltage, and then the microcontroller configures the I/O port as having high impedance, so that the energy stored in the inductor flows through the IR LED circuit.

In the infrared circuit for the single battery and the remote controller using the same according to the preferred embodiment of the invention, the inductor comprises a first end and a second end, and the IR LED circuit comprises an anode end and a cathode end. The first end of the inductor is coupled to the battery voltage, the second end of the inductor is coupled to the I/O port of the microcontroller, the cathode end of the IR LED circuit is coupled to the battery voltage, and the anode end of the IR LED circuit is coupled to the I/O port of the microcontroller. A common voltage end of the microcontroller is coupled to the common voltage. When the infrared rays are emitted, the microcontroller controls the I/O port to output a common voltage, and then the microcontroller configures the I/O port as having high impedance, so that the energy stored in the inductor flows through the IR LED circuit.

The essence of the invention is to utilize the inductor to store the energy. In addition, the current of the inductor must be continuous, thereby forcing the energy stored by the inductor to flow through the IR LED circuit. Thus, even if one single battery is used, the IR LED circuit may also be driven through the inductor. Even if the voltage of the single battery is smaller than the threshold voltage of the IR LED circuit, the IR LED circuit also can be driven through the inductor.

Further scope of the applicability of the present invention will become apparent from the detailed description given hereinafter. However, it should be understood that the detailed description and specific examples, while indicating preferred embodiments of the present invention, are given by way of illustration only, since various changes and modifications within the spirit and scope of the present invention will become apparent to those skilled in the art from this detailed description.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. **1** is a circuit diagram showing a conventional device having an infrared emitting function.

FIG. **2** is a circuit diagram showing a remote controller according to a preferred embodiment of the invention.

FIG. **3** is a circuit diagram showing an infrared circuit **203** for one single battery according to a preferred embodiment of the invention.

FIG. **4** shows an operation waveform chart of the infrared circuit **203** for one single battery according to a preferred embodiment of the invention.

FIG. **4**A is a schematic view showing a current of the infrared circuit **203** during the time T**41** according to a preferred embodiment of the invention.

FIG. **4**B is a schematic view showing a current of the infrared circuit **203** during the time T**42** according to a preferred embodiment of the invention.

FIG. **5** is a circuit diagram showing the infrared circuit **203** for one single battery according to a preferred embodiment of the invention.

FIG. **6** shows an operation waveform chart of the infrared circuit **203** according to a preferred embodiment of the invention.

FIG. **6**A is a schematic view showing a current of the infrared circuit **203** during the time T**61** according to a preferred embodiment of the invention.

FIG. **6**B is a schematic view showing a current of the infrared circuit **203** during the time T**62** according to a preferred embodiment of the invention.

FIG. **7** is a circuit diagram showing the infrared circuit **203** for one single battery according to a preferred embodiment of the invention.

FIG. **8** shows an operation waveform chart of the infrared circuit **203** according to a preferred embodiment of the invention.

FIG. **8**A is a schematic view showing a current of the infrared circuit **203** during the time T**81** according to a preferred embodiment of the invention.

FIG. **8**B is a schematic view showing a current of the infrared circuit **203** during the time T**82** according to a preferred embodiment of the invention.

FIG. **9** is a circuit diagram showing the infrared circuit **203** for one single battery according to a preferred embodiment of the invention.

FIG. **10** is a detailed circuit diagram showing the infrared circuit **203** for one single battery according to a preferred embodiment of the invention.

FIG. **11** shows an operation waveform chart of the infrared circuit **203** of FIG. **10** according to a preferred embodiment of the invention.

DETAILED DESCRIPTION OF THE INVENTION

FIG. **2** is a circuit diagram showing a remote controller according to a preferred embodiment of the invention. Referring to FIG. **2**, the remote controller comprises a button **201** or a set of buttons **201**, a single battery **202** and an infrared (IR) circuit **203** for one single battery according to the embodiment of the invention. FIG. **3** is a circuit diagram showing the infrared circuit **203** for the one single battery according to a preferred embodiment of the invention. Referring to FIG. **3**, the infrared circuit **203** comprises an IR light-emitting diode (LED) circuit **301**, an inductor **302** and a microcontroller **303**. In addition, for the sake of description, FIG. **3** also shows the single battery **202** and the button **201**. The button **201** is coupled to the microcontroller **303**. An anode of the IR LED circuit **301** is coupled to an I/O port IOP of the microcontroller **303**. A cathode of the IR LED circuit **301** is coupled to a common voltage VCOM. In this embodiment, a threshold voltage of the IR LED circuit **301** is higher than a battery voltage VBAT. A first end of the inductor **302** is coupled to the battery voltage VBAT, and a second end of the inductor **302** is coupled to the I/O port IOP of the microcontroller **303**. A power source end VDD of the microcontroller **303** is coupled to the battery voltage VBAT, and the ground GND of the microcontroller **303** is coupled to the common voltage VCOM.

FIG. **4** shows an operation waveform chart of the infrared circuit **203** for one single battery according to a preferred embodiment of the invention. Referring to FIG. **4**, in order to simplify the description, it is assumed that the button **201** generally outputs a series of infrared pulses when the button **201** is pressed down. For the sake of explanation in this embodiment, the infrared circuit **203** outputs one infrared pulse. A waveform **401** represents the waveform of the I/O port IOP of the microcontroller **303**; and a waveform **402** represents a current waveform of the inductor **302**. When the button **201** is pressed down, the microcontroller **303** controls the I/O port to switch from a high impedance state to a logic low voltage. At this time, charging of the inductor **302** starts. During the time T**41**, the current of the inductor **302** linearly rises. During this time, the current IL of the inductor **302** is shown in FIG. **4**A. FIG. **4**A is a schematic view showing a current of the infrared circuit **203** during the time T**41** according to a preferred embodiment of the invention.

When the I/O port IOP switches from the logic low voltage to the high impedance state, the current of the inductor **302** needs to be continuous. So, during the time T**42**, the current of the inductor **302** flows from the anode of the IR LED circuit **301** to the common voltage VCOM, and the current of the inductor **302** linearly decreases. During this time, the current IL of the inductor **302** is shown in FIG. **4**B. FIG. **4**B is a schematic view showing a current of the infrared circuit **203** during the time T**42** according to a preferred embodiment of the invention. Thus, even if only one single battery **201** is used, the IR LED circuit **301** still can be driven to emit the infrared signal.

FIG. **5** is a circuit diagram showing the infrared circuit **203** for one single battery according to a preferred embodiment of the invention. Referring to FIG. **5**, the infrared circuit **203** for one single battery comprises an IR LED circuit **501**, an inductor **502** and a microcontroller **503**, In addition, for the sake of description, FIG. **5** further depicts the single battery **202** and the button **201**. The button **201** is coupled to the microcontroller **503**. An anode of the IR LED circuit **501** is coupled to the battery voltage VBAT, and a cathode of the IR LED circuit **501** is coupled to an I/O port IOP of the microcontroller **503**. A first end of the inductor **502** is coupled to the I/O port IOP of the microcontroller **503**, and a second end of the inductor **502** is coupled to the common voltage VCOM. A power source end VDD of the microcontroller **503** is coupled to the battery voltage VBAT, and a ground GND of the microcontroller **503** is coupled to the common voltage VCOM.

FIG. **6** shows an operation waveform chart of the infrared circuit **203** according to a preferred embodiment of the invention. Referring to FIG. **6**, in order to simplify the description, it is assumed that the button **201** generally outputs a series of infrared pulses when the button **201** is pressed down. In this embodiment, for the sake of explanation, the infrared circuit **203** for one single battery outputs one infrared pulse. A waveform **601** represents a waveform of the I/O port IOP of the microcontroller **503**; and a waveform **602** represents a current waveform of the inductor **502**. When the button **201** is pressed down, the microcontroller **503** controls the I/O port to switch from the high impedance state to the logic high voltage. At this time, charging of the inductor **502** starts, and the current linearly rises during the time T**61**. During this time, a current IL of the inductor **502** is shown in FIG. **6**A. FIG. **6**A is a schematic view showing a current of the infrared circuit **203** during the time T**61** according to a preferred embodiment of the invention.

When the I/O port IOP switches from the logic high voltage to the high impedance state, the current of the inductor **502** flows from the anode of the IR LED circuit **501** to the common voltage VCOM, and the current of the inductor **502** linearly decreases during the time T**62** because the current of the inductor **502** needs to be continuous. During this time, the current IL of the inductor **502** is shown in FIG. **6**B. FIG. **6**B is a schematic view showing a current of the infrared circuit **203** during the time T**62** according to a preferred embodiment of the invention. Thus, even if only one single battery **201** is used, the IR LED circuit **501** also can be driven to emit the infrared signal.

FIG. **7** is a circuit diagram showing the infrared circuit **203** for one single battery according to a preferred embodiment of the invention. Referring to FIG. **7**, the infrared circuit **203** for one single battery comprises an IR LED circuit **701**, an inductor **702** and a microcontroller **703**. In addition, for the sake of description, FIG. **7** further depicts the single battery **202** and the button **201**. The button **201** is coupled to the microcontroller **703**. The anode of the IR LED circuit **701** is coupled to the I/O port IOP of the microcontroller **703**, and the cathode of the IR LED circuit **701** is coupled to the battery voltage VBAT. The first end of the inductor **702** is coupled to the battery voltage VBAT, and the second end of the inductor **702** is coupled to the I/O port IOP of the microcontroller **703**. The power source end VDD of the microcontroller **703** is coupled to the battery voltage VBAT, and the ground GND of the microcontroller **703** is coupled to the common voltage VCOM.

FIG. **8** shows an operation waveform chart of the infrared circuit **203** according to a preferred embodiment of the invention. Referring to FIG. **8**, in order to simplify the description, it is assumed that when the button **201** is pressed down, a series of infrared pulses are generally outputted. In this embodiment, for the sake of explanation, the infrared circuit **203** for one single battery outputs one infrared pulse. A waveform **801** represents a waveform of the I/O port IOP of the microcontroller **703**; and a waveform **802** represents a current waveform of the inductor **702**. When the button **201** is pressed down, the microcontroller **703** controls the I/O port to switch from a high impedance state to a logic low voltage. At this time, charging of the inductor **702** starts. During the time T**81**, the current linearly rises. During this time, the current IL of the inductor **702** is shown in FIG. **8**A. FIG. **8**A is a schematic view showing a current of the infrared circuit **203** during the time T**81** according to a preferred embodiment of the invention.

When the I/O port IOP switches from the logic low voltage to the high impedance state, because the current of the inductor **702** needs to be continuous, the current of the inductor **702** flows from the anode of the IR LED circuit **701** to the battery voltage VBAT, and the current of the inductor **702** linearly decreases during the time T**82**. During this time, the current IL of the inductor **702** is shown in FIG. **8**B. FIG. **8**B is a schematic view showing a current of the infrared circuit **203** during the time T**82** according to a preferred embodiment of the invention. Thus, even if only one single battery **201** is used, the IR LED circuit **701** may also be driven to emit the infrared signal.

Although the above-mentioned three embodiments have different connection relationships, the inductor is utilized to store the energy and then release the energy to turn on the IR LED circuit to output the infrared rays in a basic manner. Any modification, in which the IR LED circuit is coupled between the battery voltage VBAT and the common voltage VCOM, the inductor is coupled between the battery voltage VBAT and the common voltage VCOM, the microcontroller controls the battery voltage VBAT to charge the inductor through the I/O port when infrared rays are emitted, and a continuous current of the inductor forces the IR LED circuit to turn on, is regarded as falling within the scope of the invention. So, the invention is not restricted to the above-mentioned three embodiments.

FIG. **9** is a circuit diagram showing the infrared circuit **203** for one single battery according to a preferred embodiment of the invention. Referring to FIGS. **9** and **3**, the difference between the embodiments of FIGS. **9** and **3** resides in that a microcontroller **903** in the embodiment of FIG. **9** has no power source end VDD, and that the microcontroller **903** has a first I/O port IOP**1** and a second I/O port IOP**2**. In addition, a cathode of the IR LED **901** is coupled to the second I/O port IOP**2** of the microcontroller **903**. An inductor **902** is similarly coupled between the battery voltage VBAT and the first I/O port IOP**1** of the microcontroller **903**. In this embodiment, the microcontroller **903** receives the electric power for working through its first I/O port IOP**1**.

FIG. **10** is a detailed circuit diagram showing the infrared circuit **203** for one single battery according to a preferred embodiment of the invention. Referring to FIG. **10**, the inside of the dashed line is the inside of the microcontroller **903**, and the outside of the dashed line is the external circuit. In this embodiment, the microcontroller **903** has a P-type metal-oxide-semiconductor field-effect transistor (MOSFET) MP**1**, a first N-type MOSFET MN**1** and a second N-type MOSFET MN**2**, wherein the P-type MOSFET MP**1** has a parasitic diode DP**1**.

FIG. **11** shows an operation waveform chart of the infrared circuit **203** of FIG. **10** according to a preferred embodiment of the invention. Referring to FIGS. **10** and **11**, VBAT represents a battery voltage; VDDM represents a power voltage of the microcontroller **903**; PG**1** represents a signal given to the gate of the P-type MOSFET MP**1**; NG**1** represents a signal given to the gate of the first N-type MOSFET MN**1**; NG**2** represents a signal given to the gate of the second N-type MOSFET MN**1**; IL represents a current flowing through the inductor **902**; IIR represents a current flowing through the IR LED **901**; IMP represents a current flowing through the P-type MOSFET MP**1**; WKUP represents a wake-up enable signal of the microcontroller **903**; and LVRB represents a low voltage reset signal.

Similarly, it is assumed that the infrared circuit **203** for one single battery is an infrared ray remote controller. When no remote control operation is performed, the microcontroller **903** is in a standby state, and the operation voltage thereof only needs to be 0.9V. When the user presses the button, a wake-up signal WKUP is enabled. At this time, the gate of the first N-type MOSFET MN**1** is given with a switch signal NG**1** of the frequency of 250 KHz, and the gate of the second N-type MOSFET MN**2** is given with the logic low voltage NG**2**, so the second N-type MOSFET MN**2** is in an off state. When the first N-type MOSFET MN**1** turns off, the current of the inductor **902** charges the power voltage VDDM of the microcontroller **903** through the parasitic diode DP**1** of the P-type MOSFET MP**1**.

After the time T**1** has elapsed and when the power voltage of the microcontroller **903** VDDM is charged to 2.2V, waiting is performed for the time T**2**, and then the low voltage reset signal LVRB is enabled and the microcontroller **903** is reset. Thereafter, the transmission of the remote control signal of 38 KHz starts. When the transmission of the remote control signal of 38 KHz starts, the second N-type MOSFET MN**2** is turned on. At this time, the gate of the first N-type MOSFET MN**1** is given with the switch signal NG**1** of the frequency 38 KHz. Because the second N-type MOSFET MN**2** is turned on, the current of the inductor **902** flows to the IR LED **901** to emit the IR optical signal. Also, please refer to the symbol **1101**. In each period the second N-type MOSFET MN**2** is turned off, the gate of the first N-type MOSFET MN**1** is given with the switch signal NG**1** (short pulse) of the frequency 250 KHz. Thus, the inductor can charge the power voltage VDDM of the microcontroller **903**.

When the signal output is completed, the low voltage reset signal LVRB is switched from the logic high voltage to the logic low voltage, the switching of the switch signal NG**1** given to the gate of the first N-type MOSFET MN**1** and the switch signal NG**2** given to the second N-type MOSFET MN**2** stops, and the microcontroller **903** again returns to the standby state.

The more special property is that the microcontroller **903** of this embodiment does not need additional power voltage pins. The microcontroller **903** utilizes the first N-type MOSFET MN**1** inside the first I/O port IOP**1** to switch to make the inductor continuously charge/discharge, so that the microcontroller **903** can obtain the enough power voltage. In addition, the power voltage of the microcontroller **903** is again charged each time after the remote control signal of 38 KHz is transmitted in the above-mentioned embodiment. However, this implementation is only the preferred implementation. If the power voltage is stable, it is not necessary to charge the power voltage of the microcontroller **903** each time after the remote control signal of 38 KHz is transmitted. The invention is not restricted thereto. Furthermore, although the above-mentioned embodiment charges the microcontroller with the frequency of 250 KHz, those skilled in the art should know that the frequency relates to the inductance or other parameters, and is unnecessary to be kept at 250 KHz. So, the invention is not restricted thereto. Similarly, although 38 KHz is the frequency of the existing infrared receiver, the invention can also be applied to other applications. If other frequency bands are used in other applications, the invention may also be implemented at other frequencies. So, the invention is not restricted thereto.

In summary, the essence of the invention is to utilize the inductor to store the energy. In addition, because the current of the inductor needs to be continuous, the stored energy is forced to flow through the IR LED circuit. Thus, even if one single battery is used, the IR LED circuit also can be driven through the inductor. Even if the battery voltage of the single battery is lower than the threshold voltage of the IR LED circuit, the IR LED circuit also can be driven through the inductor.

While the present invention has been described by way of examples and in terms of preferred embodiments, it is to be understood that the present invention is not limited thereto. To the contrary, it is intended to cover various modifications. Therefore, the scope of the appended claims should be accorded the broadest interpretation so as to encompass all such modifications.

What is claimed is:

1. An infrared (IR) circuit to be driven by only one single battery, which outputs a battery voltage, the infrared circuit comprising:

an IR light-emitting diode (LED) circuit coupled between the battery voltage and a common voltage;

an inductor coupled between the battery voltage and the common voltage; and

a microcontroller comprising an input/output (I/O) port coupled to the inductor and the IR LED circuit, wherein,

when infrared rays are emitted, the microcontroller controls the battery voltage to charge the inductor through the I/O port, and utilizes a continuous current of the inductor to force the IR LED circuit to turn on.

2. The infrared circuit according to claim **1**, wherein the inductor comprises a first end and a second end, the IR LED circuit comprises an anode end and a cathode end, the first end of the inductor is coupled to the battery voltage, the second end of the inductor is coupled to the I/O port of the microcontroller, the anode end of the IR LED circuit is coupled the I/O port of the microcontroller, and the cathode end of the IR LED circuit is coupled to the common voltage.

3. The infrared circuit according to claim **2**, wherein when the infrared rays are emitted, the microcontroller controls the I/O port to output the common voltage, and then the microcontroller configures the I/O port as having high impedance, so that energy stored in the inductor flows through the IR LED circuit.

4. The infrared circuit according to claim **1**, wherein the inductor comprises a first end and a second end, the IR LED circuit comprises an anode end and a cathode end, the first end of the inductor is coupled to the common voltage, the second end of the inductor is coupled to the I/O port of the microcontroller, the anode end of the IR LED circuit is coupled to the battery voltage, and the cathode end of the IR LED circuit is coupled to the I/O port of the microcontroller.

5. The infrared circuit according to claim **4**, wherein when the infrared rays are emitted, the microcontroller controls the I/O port to output a power voltage, and then the microcontroller configures the I/O port as having high impedance, so that energy stored in the inductor flows through the IR LED circuit.

6. The infrared circuit according to claim **1**, wherein the inductor comprises a first end and a second end, the IR LED circuit comprises an anode end and a cathode end, the first end of the inductor is coupled to the battery voltage, the second end of the inductor is coupled to the I/O port of the microcontroller, the cathode end of the IR LED circuit is coupled to the battery voltage, and the anode end of the IR LED circuit is coupled to the I/O port of the microcontroller, wherein a common voltage end of the microcontroller is coupled to the common voltage.

7. The infrared circuit according to claim **6**, wherein when the infrared rays are emitted, the microcontroller controls the I/O port to output the common voltage, and then the microcontroller configures the I/O port as having high impedance, so that energy stored in the inductor flows through the IR LED circuit.

8. The infrared circuit according to claim 1, wherein the microcontroller comprises a second I/O port, wherein,

the inductor comprises a first end and a second end, the IR LED circuit comprises an anode end and a cathode end, the first end of the inductor is coupled to the battery voltage, the second end of the inductor is coupled to the I/O port of the microcontroller, the anode end of the IR LED circuit is coupled to the I/O port of the microcontroller, and the cathode end of the IR LED circuit is coupled to a second I/O port of the microcontroller,

wherein the I/O port of the microcontroller comprises:

a first switch, comprising a control end, a first end and a second end, wherein the control end of the first switch receives a first control signal inside the microcontroller, to control on and off states between the first end of the first switch and the second end of the first switch, the first end of the first switch is coupled to the I/O port, and the second end of the first switch is coupled to the common voltage end; and

a unidirectional conductive element comprising a first end and a second end, wherein the first end of the unidirectional conductive element is coupled to the I/O port, and the second end of the unidirectional conductive element is coupled to a power voltage of the microcontroller;

wherein the second I/O port of the microcontroller comprises:

a second switch comprising a control end, a first end and a second end, wherein the control end of the second switch receive a second control signal from the microcontroller, to control on and off states between the first end of the second switch and the second end of the second switch, the first end of the second switch is coupled to the second I/O port, and the second end of the second switch is coupled to the common voltage end;

wherein when the microcontroller is waken up, the microcontroller controls the second control signal to turn off the second switch, and the microcontroller controls the first control signal to control switching of the first switch by a charging frequency to charge the power voltage of the microcontroller,

wherein when infrared data is transmitted, the microcontroller controls the second switch to turn on, the microcontroller controls a frequency and a logic voltage of the first control signal according to the infrared data, and controls the on and off states between the first end and the second end of the first switch to make the IR LED circuit output the infrared data.

9. The infrared circuit according to claim 8, wherein when the infrared data is transmitted and the second switch turns off, the microcontroller controls the first control signal to operate at the charging frequency, and controls the first switch to switch to charge the power voltage of the microcontroller.

10. A remote controller, comprising:

a button;

a single battery outputting a battery voltage; and

an infrared circuit for the single battery, comprising:

an IR LED circuit coupled between the battery voltage and a common voltage;

an inductor coupled between the battery voltage and the common voltage; and

a microcontroller, which is coupled to the button and comprises an I/O port, wherein the I/O port of the microcontroller is coupled to the inductor and the IR LED circuit, wherein,

when the button is pressed down, the microcontroller controls the IR LED circuit to emit infrared rays according to the pressed button, wherein,

when the infrared rays are emitted, the microcontroller controls the battery voltage to charge the inductor through the I/O port, and utilizes a continuous current of the inductor to force the IR LED circuit to turn on.

11. The remote controller according to claim 10, wherein the inductor comprises a first end and a second end, the IR LED circuit comprises an anode end and a cathode end, the first end of the inductor is coupled to the battery voltage, the second end of the inductor is coupled to the I/O port of the microcontroller, the anode end of the IR LED circuit is coupled to the I/O port of the microcontroller, and the cathode end of the IR LED circuit is coupled to the common voltage.

12. The remote controller according to claim 11, wherein when the infrared rays are emitted, the microcontroller controls the I/O port to output the common voltage, and then the microcontroller configures the I/O port as having high impedance, so that energy stored in the inductor flows through the IR LED circuit.

13. The remote controller according to claim 10, wherein the inductor comprises a first end and a second end, the IR LED circuit comprises an anode end and a cathode end, the first end of the inductor is coupled to the common voltage, the second end of the inductor is coupled to the I/O port of the microcontroller, the anode end of the IR LED circuit is coupled to the battery voltage, and the cathode end of the IR LED circuit is coupled to the I/O port of the microcontroller.

14. The remote controller according to claim 13, wherein when the infrared rays are emitted, the microcontroller controls the I/O port to output a power voltage, and then the microcontroller configures the I/O port as having high impedance, so that energy stored in the inductor flows through the IR LED circuit.

15. The remote controller according to claim 10, wherein the inductor comprises a first end and a second end, the IR LED circuit comprises an anode end and a cathode end, the first end of the inductor is coupled to the battery voltage, the second end of the inductor is coupled to the I/O port of the microcontroller, the cathode end of the IR LED circuit is coupled to the battery voltage, and the anode end of the IR LED circuit is coupled to the I/O port of the microcontroller, wherein a common voltage end of the microcontroller is coupled to the common voltage.

16. The remote controller according to claim 15, wherein when the infrared rays are emitted, the microcontroller controls the I/O port to output the common voltage, and then the microcontroller configures the I/O port as having high impedance, so that energy stored in the inductor flows through the IR LED circuit.

17. The remote controller according to claim 10, wherein the microcontroller comprises a second I/O port, wherein,

the inductor comprises a first end and a second end, the IR LED circuit comprises an anode end and a cathode end, the first end of the inductor is coupled to the battery voltage, the second end of the inductor is coupled to the I/O port of the microcontroller, the anode end of the IR LED circuit is coupled to the I/O port of the microcontroller, and the cathode end of the IR LED circuit is coupled to a second I/O port of the microcontroller, wherein the I/O port of the microcontroller comprises:

a first switch comprising a control end, a first end and a second end, wherein the control end of the first switch receives a first control signal inside the microcontroller to control on and off states between the first end of the first switch and the second end of the first switch, the first end of the first switch is coupled to the I/O port, and the second end of the first switch is coupled to the common voltage end; and

a unidirectional conductive element comprising a first end and a second end, wherein the first end of the unidirectional conductive element is coupled to the I/O port, and the second end of the unidirectional conductive element is coupled to a power voltage of the microcontroller;

wherein the second I/O port of the microcontroller comprises:

a second switch comprising a control end, a first end and a second end wherein the control end of the second switch receives a second control signal from the microcontroller to control on and off states between the first end of the second switch and the second end of the second switch, the first end of the second switch is coupled to the second I/O port, and the second end of the second switch is coupled to the common voltage end;

wherein when the microcontroller is waken up, the microcontroller controls the second control signal to turn off the second switch, and the microcontroller controls the first control signal to control switching of the first switch by a charging frequency to charge a power voltage of the microcontroller,

wherein when infrared data is transmitted, the microcontroller controls the second switch to turn on, and the microcontroller controls a frequency and a logic voltage of the first control signal according to the infrared data, and controls the on and off states between the first end and the second end of the first switch to make the IR LED circuit output the infrared data.

18. The remote controller according to claim **17**, wherein when the infrared data is transmitted and the second switch turns off, the microcontroller controls the first control signal to operate at the charging frequency and controls the first switch to switch to charge the power voltage of the microcontroller.

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